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TERMINOLOGY OF THE UREDINALES

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As the knowledge of the rusts developed to the stage where more than one spore-form was recognized as belonging to a species, it became advantageous to employ generalized terms. For this reason the term teleutospore met with ready acceptance. It signified the last spore-form in the series, the sorus in which such spores were formed being called a teleutosorus. The serial position of other kinds of spores was not so readily apparent. Consequently no important attempt was made to extend this method of naming the several classes of spores, but instead, generic names were brought into use, such as uredospore and aecidiospore. It required no explanation that spores from an *Aecidium* were to be called aecidiospores, but what about spores from a *Peridermium* or a *Caeoma?* Logically they should be called respectively peridermiospores and caeomospores. In this way there came into use terms to cover nearly as many kinds of spores as there were generic names recognized, even going so far as to infringe upon the domain of the teleutospore with the term pucciniospore.

The reaction to this multifarious terminology arose from the recognition that many apparently diverse structures possessed a general similarity to the best known forms of *Aecidium,* both in form and function, and so the term aecidiospore was often made to cover nearly all catenulate spores borne in a peridium. When the peridium was absent they were usually called caeomospores; and stylosporic forms with or without a peridium were generally called uredospores. With this reduction of terms came the growing impression that the first two terms covered a primary form of spore, and that uredospores were a secondary form, sometimes considered as essentially conidia, leaving the term teleutospore to designate a third or final form.

[1] Contribution from the Purdue University Agricultural Experiment Station.

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This terminology worked fairly well with many of the most common and familiar genera, but had to be stretched to apply to the catenulate, verrucose spores without a peridium in the genus *Coleosporium*, and served very poorly in less familiar genera, such as *Kuehneola*, *Pucciniosira*, etc.

Thus the matter stood when in 1905 the writer[2] proposed new terms to replace a multiplicity of old terms, and more clearly to bring out homologies in the different stages in the life histories of the rusts. Instead of the prevailing terms which were mostly derived from generic names, the four terms: pycnium (from πυκνός, solid or compact), aecium (from αἰκία, an injury), uredinium (from *uredo*, a blight or blast), and telium (from τέλειος or τέλεος, complete or perfect), were designed to cover the different sorts of sori in every full spored, long cycle rust. The names of the spores were derived in all cases from the sori bearing them, without regard to form, surface markings, or accessories, and were respectively pycniospores, aeciospores, urediniospores, and teliospores. That these terms have proved serviceable is evident from the increasing number of mycologists who employ them.

It may be that the reason why others do not use the new terms, aside from natural inertia or undue conservatism, is the belief held by some that the terms spermogonium, aecidium, uredosorus, and telosorus have come to have such definite application and to convey such clear concepts that there is no need of a new set of terms. In fact, to them a new set of terms really makes a difficult situation still more confusing. Even if we grant that such is the case, which is much to be doubted, yet the cumbersome form of the old names and their lack of uniformity fail to commend them.

In order to show what concepts underlie the new terminology, as well as its application, the following explanation is given. First let it be borne in mind that the new terms do not merely replace the older ones, but that they stand upon a distinctly different basis. In the first place, the terms primarily apply to the sorus, and not, as with the old terms, chiefly to the spores and their accessories. While this was the intent when the terms were first announced, yet only

[2] ARTHUR, J. C., Terminology of the spore-structures in the Uredinales. BOT. GAZ. 39:219. 1905.

within a few years have facts been available to make possible a full demonstration of the correctness of this position. Very little was known regarding the origin and intimate structure of the several forms of sori in 1905, most of the knowledge being derived from the studies of SAPPIN-TROUFFY, BLACKMAN, and CHRISTMAN, who were chiefly interested in the behavior of the nucleus. The work of a gradually increasing number of cytologists during the intervening two decades now justifies the statement that the four kinds of sori are built upon essentially the same plan. In brief, each sorus arises from a primordium, which differentiates a hymenial layer that produces spores from its upper surface. This is equally true of a pycnium or a telium, of an aecium, whether in the form of the simplest *Caeoma* or the most complex *Aecidium*, and of a uredinium, whether conidial in appearance or provided with a peridium and catenulate spores. In each of the four kinds of sori there may be more or less highly developed accessories, such as pseudoparenchyma, buffer cells, paraphyses, peridium, etc., partly evanescent and partly permanent. This essential similarity in the fundamental structure of the four kinds of sori is reflected in the similarity of the new names applied to them.

All rusts, whatever their appearance or diversity of spore-forms, pass through a two-phase life cycle: the gametophytic phase with usually uninucleate mycelium, and the sporophytic phase with usually binucleate mycelium. Every species of rust having the ancestral, long cycle development without exception terminates the first or gametophytic phase with a sorus, the aecium, in which cell fusion takes place, giving rise to binucleate spores, while the second or sporophytic phase is terminated by another sorus, the telium, in which the two nuclei of the spores, which have descended from the aecium, are at maturity fused into one. The first, or gametophytic phase, bears another form of sorus, the pycnium, if not lost in retrograde development, which in the dim ancestral uredinalean past may have been a male organ of reproduction, but now is functionless. It is uninucleate throughout. The second, or sporophytic phase, bears still another form of sorus, if not lost in retrograde development, the uredinium, which is of a repeating or conidial nature. It is binucleate throughout. To recapitulate: every long cycle rust, without excep-

tion, terminates its first phase of growth with an aecium, and its second phase with a telium, and to the first phase may or may not be added a pycnium, while to the second phase may or may not be added a uredinium. There are no exceptions to this general statement, except such as are due to extreme simplification or are to be considered pathogenic or abnormal.

When the two essential kinds of sori to be found in every long cycle rust, the aecium and telium, are telescoped into one, a short cycle rust is produced, with the sporophytic mycelium omitted. In the short cycle rust the first, or gametophytic phase, ends as it does in long cycle forms with fusion of cells, while the second or sporophytic phase, which is very short, ends when the two nuclei of the resulting spores fuse as these spores reach maturity. In consideration of this combined action the sorus may be called an aeciotelium. Sometimes there are pycnia with a short cycle rust, but never uredinia.

The two preceding paragraphs have been devoted to a brief elementary statement of the course of development among the rusts. All rusts of every sort are thus seen to have a two-phase development, whether long cycle with two forms of mycelium, and two to four forms of sori, in which aecia and telia are always present, or short cycle with one form of mycelium, and one or two forms of sori, aeciotelia always being present. This simple statement should be born in mind in trying to determine the application of the new terminology.

In 1905, in the preface of an important paper, HARPER[3] stated the grounds on which comparative morphology and the use of terms should proceed, as follows:

> Great confusion has arisen in the morphology of the fungi and algae from allowing considerations of functional equivalence or difference to mingle with and modify the conceptions of what should be a strictly phylogenetic morphology. If there can be agreement that the various developmental stages and fruit forms of the fungi and algae shall be classified and named in accordance with what can be determined as to their phylogeny, a number of disputed questions will disappear.

[3] HARPER, R. A., Sexual reproduction and the organization of the nucleus in certain mildews. Carnegie Inst. Wash. Publ. no. 37. 1905.

Two decades have passed since these statements were made, and before me lies a recent letter from HARPER, from which I have the privilege to quote, in which he says:

> It is the great outstanding achievement which revolutionized comparative morphology that we have come to realize that structures should be named not according to their function, but according to their morphological and phylogenetic connections.

Probably no one is likely to dispute this reiterated statement of a fundamental doctrine of the phylogenetic basis of modern morphology, certainly not the writer. The difficulty arises in the application.

The present state of knowledge indicates that in the rusts there are four kinds of sori, arising at successive intervals in the life cycle of every species having the ancestral, full spored cycle of development, all possessing a certain unity of structure, but differing in histological details, and each having its independent phylogenetic history. When a retrograde change has taken place in the historical development of a species, one or more forms of sori may be omitted from the cycle, going so far as to leave only aecia and telia in long cycle species and aeciotelia in short cycle species. Beside the definite consecutive positions in the life history held by the four sorts of sori, each has its distinctive fundamental structure, determined by the nuclear behavior. There is no gross structural character that belongs to one kind of sorus rather than to another, although certain forms are met with so frequently as to seem characteristic. The true nature of a sorus depends upon its phylogenetic position in the individual cycle and upon its nuclear structure.

It would be illuminating to take up a number of representative species and contrast the application of the old and new terms, but it seems scarcely necessary. If the emphasis in thinking of the rusts is placed upon the mycelial body and the fruit forms or sori which it bears in unvarying order, instead of upon the spore forms and their accessories, there should be no difficulty in apprehending the simplicity of the new terms and their suitableness for every possible situation, whatever bewildering likeness the spores and their accessories may suggest.

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